AMCOM CBM+
Program Overview
for the
RAM 4 Workshop

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AMCOM CBM +

PREVENTIVE	INDICATORS	DIAGNOSTICS	PROGNOSTICS	ON-CONDITION
• Digital Source Collector Installation • Health Monitoring Unit (HMU) Installation • Knowledge Development		• CI / HI Development • Flight Line Diagnostics • Institutionalized Training	• Remaining Useful Life Calculation Inspection Targeting • Mission-Based Forecasting	

CBM Program Supporting ARFORGEN

CBM Program Objectives:

- Decrease Maintenance Burden on the Soldier
- Increase Platform Availability and Readiness
- Enhance Safety
- Reduce Operations

Key CBM Enablers

- Digital Source Collectors
- Health Monitoring Units
- Flight Line
- Data Fusion/Analysis

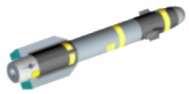
The purpose of Army Maintenance is to generate Combat Power. ***AR 750-1***

TRAIN HEALTH VIDEO

Warfighter Will Not Deploy Without

How Does It Work?

Collect, Transmit, and Store Data

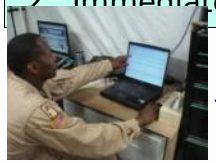


Digital Source Collectors (DSC)

1. Suite of Sensors and LRU (MSPU, ECA, IV-HMS)
2. Monitor Component Health ("EKG" of Systems Health)

2 At Platform Work Stations

1. Transfer DSC Data & Processed Information to ULLS-A(E)
2. Immediate Action Information



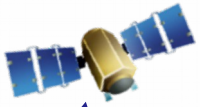
Scheduled Maintenance

Preventive Maintenance

Process and Display DSC/HMU Data

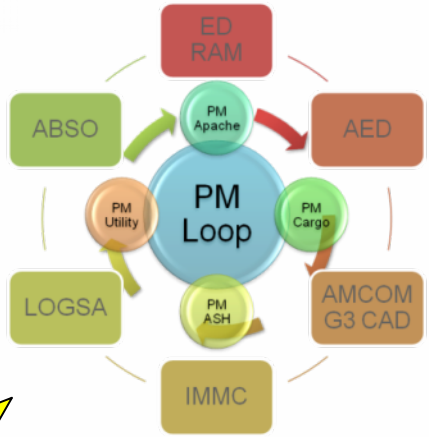
3 BN Production Contro

1. Plans Maintenance Activiti
2. Collates Unit Data
3. Portal Into STAMIS



VSAT

JTDI
op Tier Serve



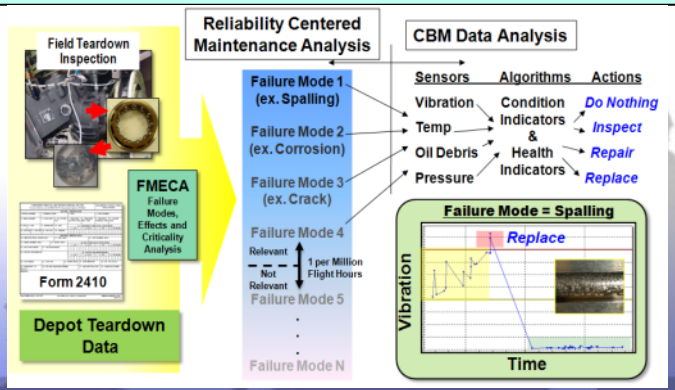
6 Actionable Maintenance & Support Information Returned to Unit

4 Data Loaded
Into CBM Data Warehouse
Flight Regime
CI Development

Data Warehouse
Failure Analysis
Prognostics

- **IETM Updates**
- **QDR Requests**
- **Aircraft Watch List**
- **Threshold Updates**
- **Safety of Flight MSG**
- **Maintenance Changes**
- **Aircraft Health Status**

5 Engineering Analysis
Component Health and Remaining Life

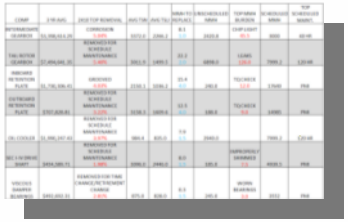


LIW

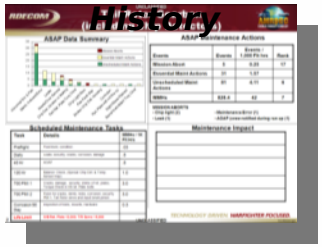
How Does It Work?

Solution Development and Selection

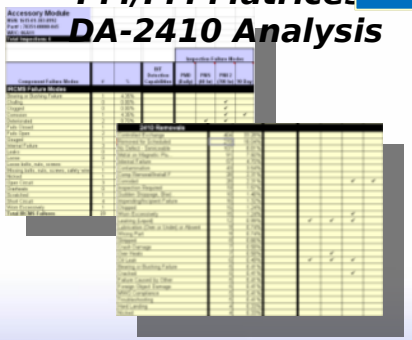
Burden Analysis



Maintenance History



PM/FM Matrices DA-2410 Analysis



Maintenance Procedure Change (ex. Gyro Diagnostics & AOAP)

Part Redesign (ex. TADS harness & K-flex coupling)

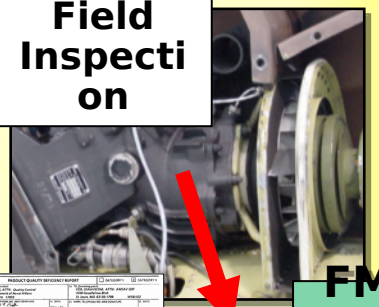
Condition Monitoring (ex. Vibration Absorbers & Drive shafts)

Bringing the whole story to system stakeholders to get the best solution to the Soldier.

How Does It Work?

Analyze & Correlate Data: DIAGNOSTICS

Field Inspection



QDR (SF-368)

FMECA Failure Modes, Effects and Criticality Analysis

Form 2410

RIMFIRE Depot Teardown Data

RCM Data Analysis

CBM Data Analysis

Failure Mode 1 (ex. Spalling)

Failure Mode 2 (ex. Corrosion)

Failure Mode 3 (ex. Crack)

Failure Mode 4

Failure Mode 5

Relevant — 1 per Million Flight Hours — Not Relevant

Sensors **Algorithms**

Actions

Vibration

Nothing

Temp

Oil Debris

Condition Indicators & Health Indicators

Do

Inspect

Failure Mode = Spalling

Replace

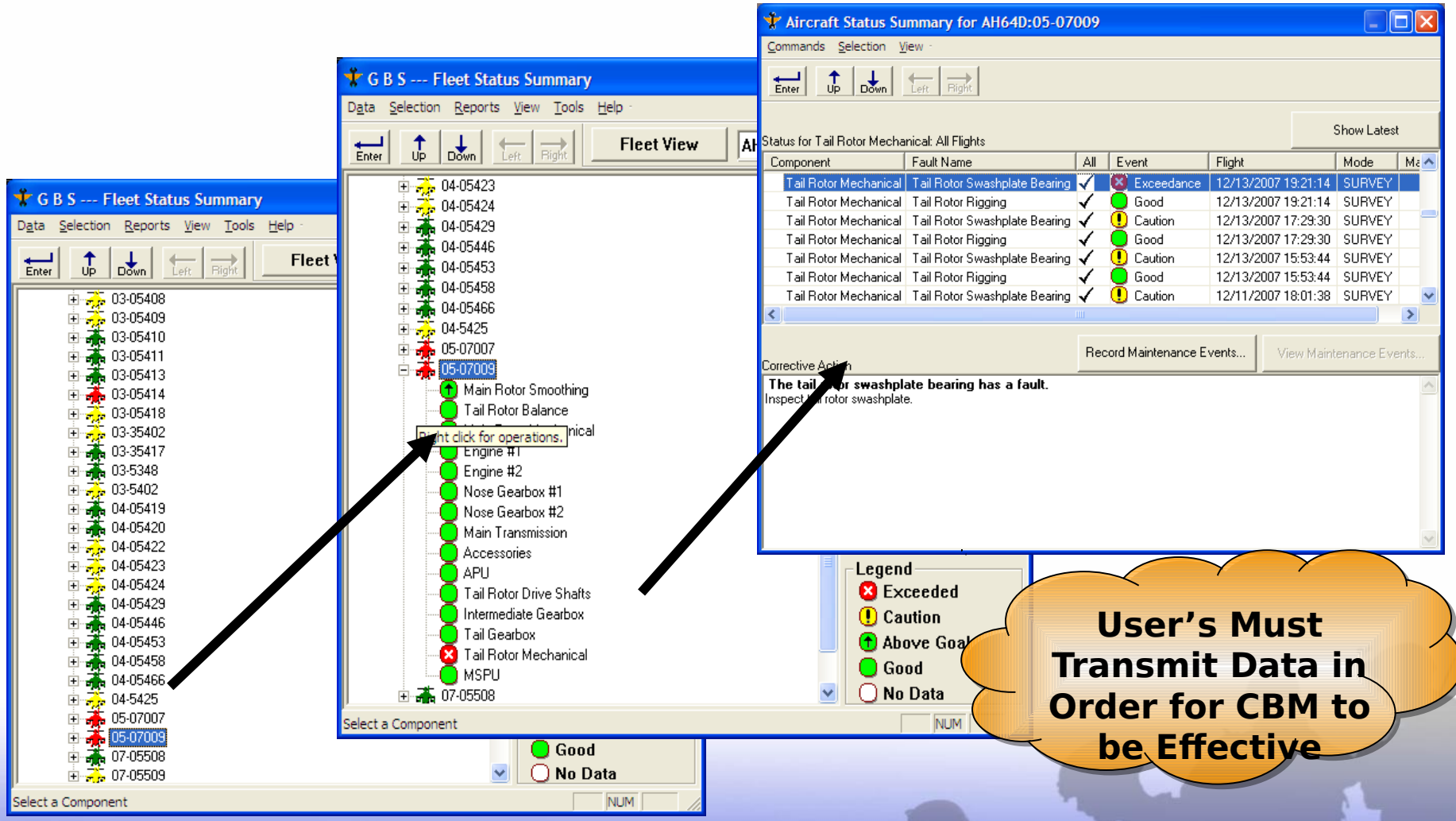
Vibration

Time

Data Analysis is Im… Develop A National Level Knowledge Foundat… Actionable Information to Mai… the Field

How Does It Work?

Provide Health Information to the User

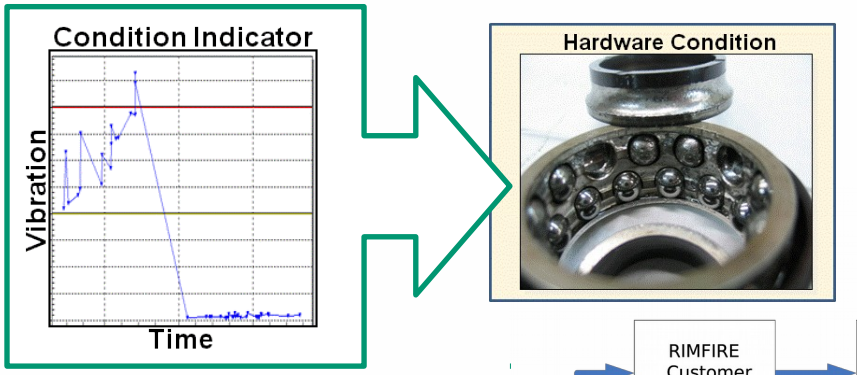


Used by Both Maintainers and Engineers

How Does It Work?

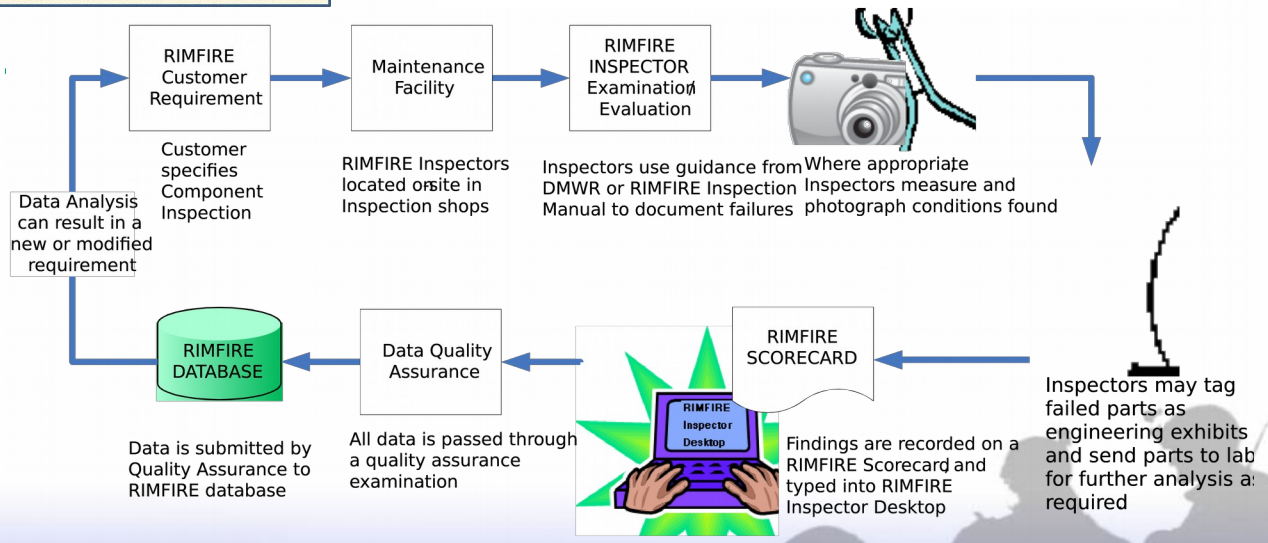
Correlate Hardware Condition to Sensor Data via RIMFIRE

RIMFIRE: Record of *Observation*



Correlation of equipment condition to indicators such as vibration sensors and metal chip detectors is necessary to improve confidence in the Health Monitoring System

RIMFIRE: Inspection Lifecycle

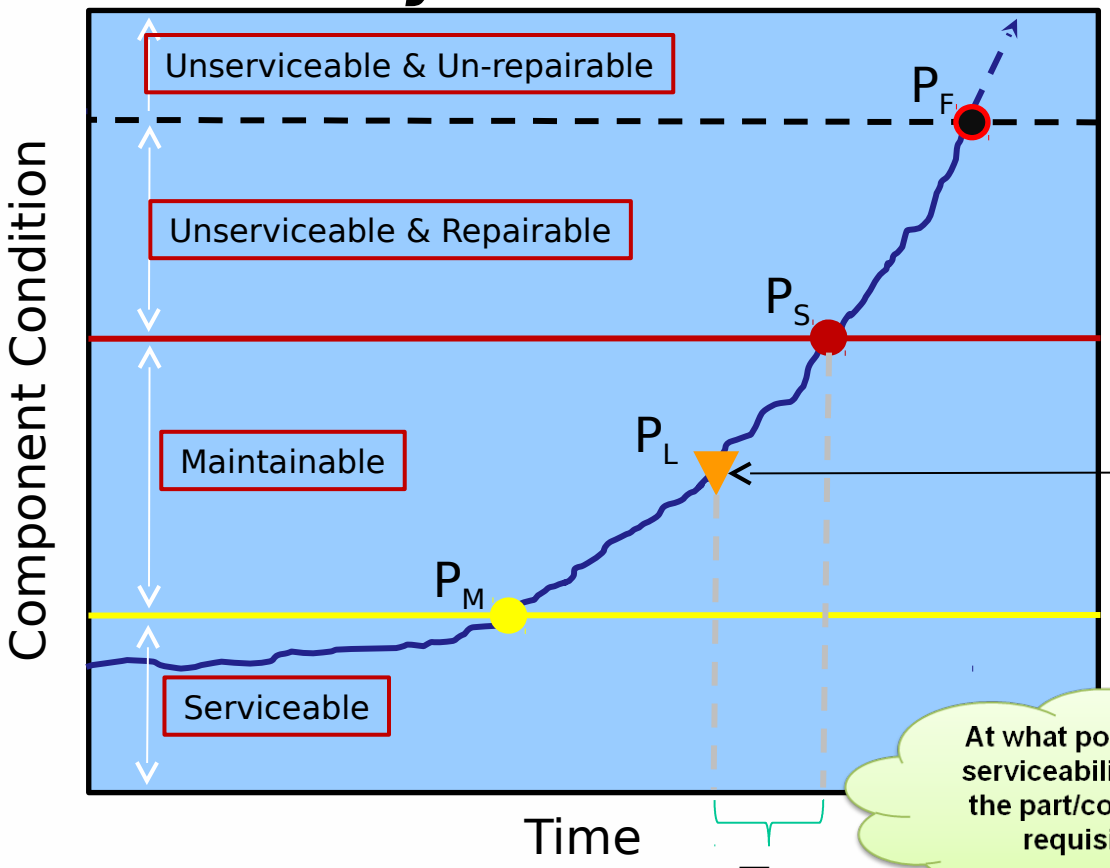

RIMFIRE Customer Requirement
Customer specifies Component Inspection
Maintenance Facility
RIMFIRE Inspectors located onsite in Inspection shops
RIMFIRE INSPECTOR Examination/ Evaluation
Inspectors use guidance from DMWR or RIMFIRE Inspection Manual to document failures
Where appropriate Inspectors measure and photograph conditions found
Inspectors may tag failed parts as engineering exhibits and send parts to lab for further analysis as required
RIMFIRE SCORECARD
Findings are recorded on a RIMFIRE Scorecard and typed into RIMFIRE Inspector Desktop
RIMFIRE Inspector Desktop
Data Quality Assurance
All data is passed through a quality assurance examination
RIMFIRE DATABASE
Data is submitted by Quality Assurance to RIMFIRE database
Data Analysis can result in a new or modified requirement

RIMFIRE data is utilized to Correlate Health/Condition Indicators with actual observed hardware condition

RIMFIRE identifies and tracks root removal cause, helps validate condition indicator thresholds and subsequently aids RCM in determining which components should be identified as

How Does It Work?

Analyze & Correlate Data: Prognostics



Component Failure Threshold: Based on Fatigue Life, Environment, Usage, Published Serviceability Limits (DMWR/FMECA)

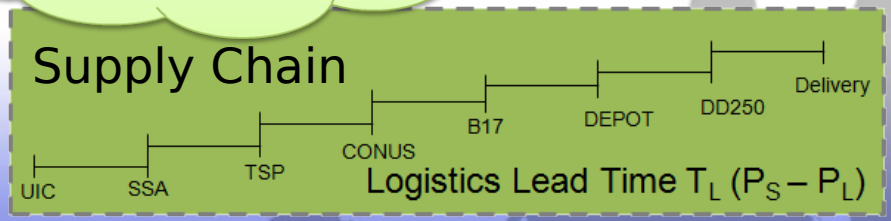
Serviceability Threshold: Based on Reparability, Usage, Published Serviceability Limits (TMs)

Requisition Threshold: Based on Availability, Demand, Unit Classification, OPTEMPO, Shipping Time (Distance from SSA), Rate of Degradation

Maintainability Threshold: Based on Preventive Maintenance Tasks, Field Serviceability, Rate of Degradation

At what point along the serviceability curve can the part/component be requisitioned?

P_F = Threshold of Component Failure:
P_S = Threshold of Component Serviceability
P_L = Threshold of Requisition
P_M = Threshold of Maintenance
T_L = Threshold of Logistics Lead Time



What Does It Do?

Army Aviation Systems

- 573 (92% of AH-64D Fleet) DSC Equipped
- 93 Monitored Components
- 58 Maintenance Tasks Eliminated
- 9.1% Fewer Mission Aborts / 100 Flight Hours

- 189 (40% of C/MH-47D/G Fleet) DSC Equipped
- 163 Monitored Components
- 4.0% Reduction in Flight Hours Dedicated to MTF

- 174 (52% of OH-58D Fleet) DSC Equipped
- 14 Monitored Components
- Significant MMH Reduction in RTB and Engine Vibration

- 1314 (68% of M/UH-60A/L/M Fleet) DSC Equipped
- 108 Monitored Components
- 9.2% Reduction in NMC-M
- 59 Maintenance Task Changes Increasing Aircraft Availability

For Every 20 CBM-Equipped Aircraft, Equivalent to 1 More Available for Missions

Decrease in Maintenance Cost & Soldier Burden

- Maintenance Test Flight Reduction 1-4%
- Over 127 Maintenance Procedures Improved or Eliminated

Gains in Readiness and Combat Power

- Experienced 3.8%-12.4% NMCM Reduction
- 1 Less Mission Abort Per 100 Flt Hrs
- 5-8% Increase in Readiness

Enhanced Safety

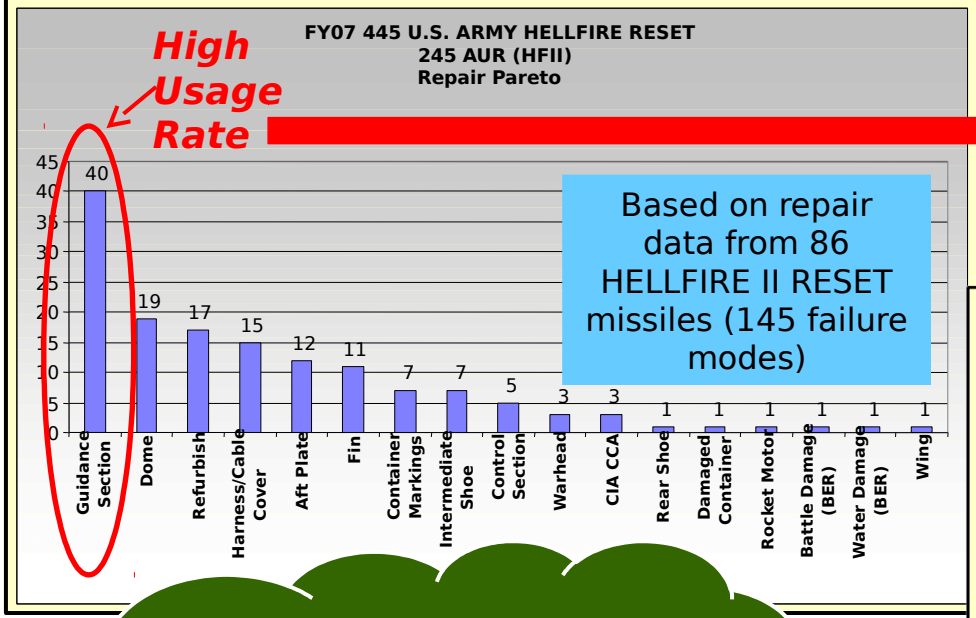
- Avoided 4 Class A (Major) Mishaps
- Predicted To Avoid 11-12 Additional Class A Mishaps Over Next 10 Years

CBM+ Generates Combat Power

What Does It Do?

Army Missile Systems (AGM-114 Hellfire)

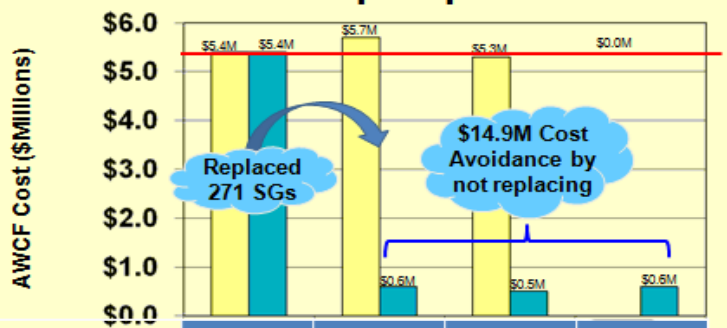
Pareto Plot of Defects - HFII



Based on repair data from 86 HELLFIRE II RESET missiles (145 failure modes)

"Captive Carry hours impact HELLFIRE performance and drive repair and RESET activities by replacing Guidance Systems only when usage i

HELLFIRE II
Sensor Group Replacement



	FY07	FY08	FY09	FY10
Planned Cost	$5.4	$5.7	$5.3	$0.0
Actual Cost	$5.4	$0.6	$0.5	$0.6
Planned SG QTY	445	322	*300*	*300*
Actual SG QTY	445	*86*	*72*	*79*

$14.9M Cost savings over 3 years
= Potential to Eliminate Many $M in Unnecessary Guidance System Replacements

Closing Remarks

We are working to:

- Take Advantage of CBM Momentum to Derive Solutions that Benefit the Soldier
- Communicate with Field Maintainers
- Relate Benefits to Metrics and ROI
- Institutionalize RCM

Questions

Backup

How Does It Work?

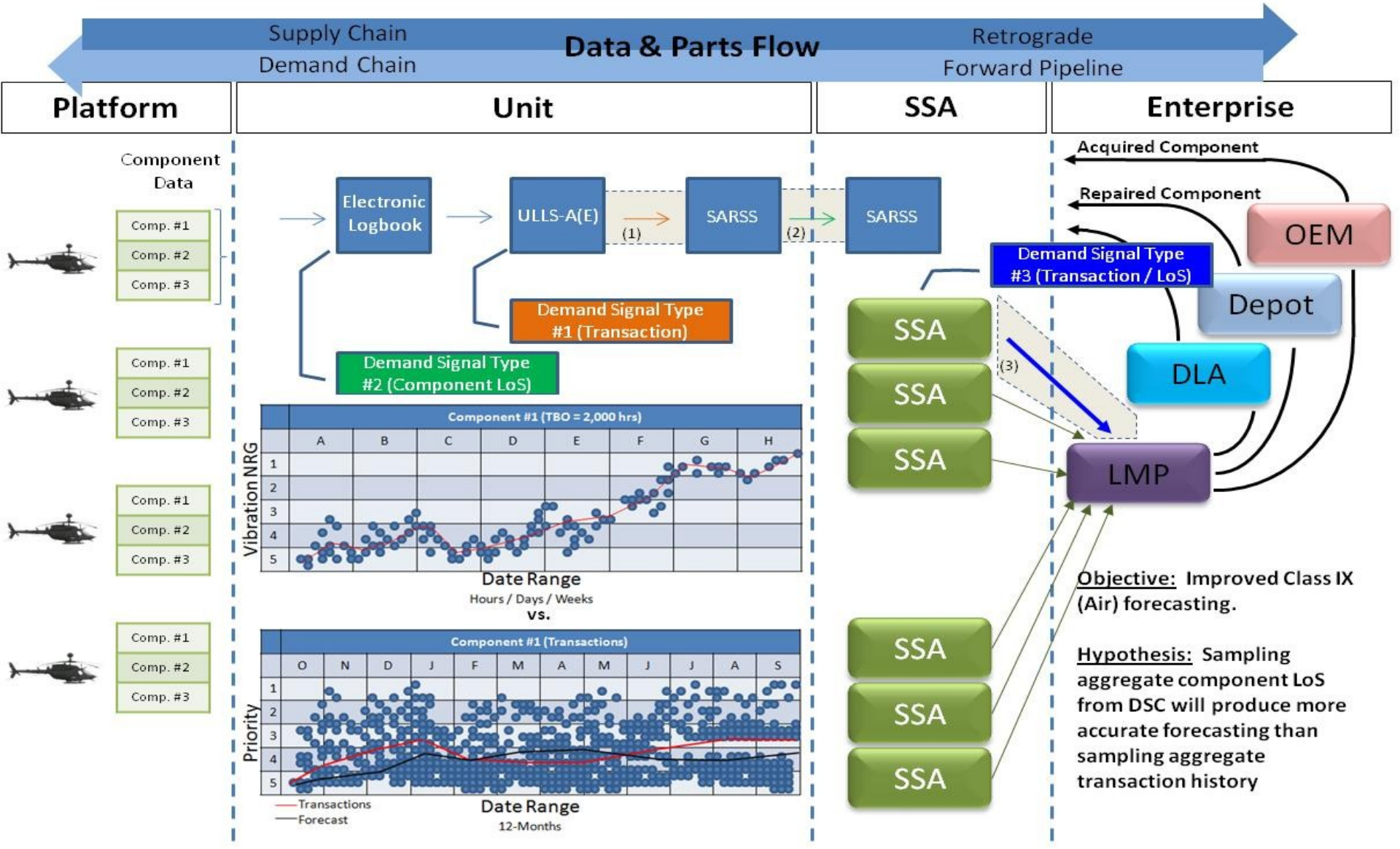
Deploy On-board Data Collectors

Aircraft Type	Total # of Aircraft	DSC Equipped		Percent Complete	Percent Complete EOY FY11	Percent Complete EOY FY12
AH-64 A *	110	0	573	*79%*	*87%*	*87%*
AH-64 D	614	573				
CH-47 D	461	126	184	*40%*	*44%*	*60%*
CH-47 F **		0				
MH-47 G		58				
UH-60 A	1862	491	1314	*71%*	*80%*	*88%*
UH-60 L		475				
UH-60 M		323				
MH-60 L		15				
MH-60M		10				
MH-6	51	15		*29%*	*59%*	*59%*
OH-58 D	336	174		*52%*	*84%*	*100%*
TOTAL	*3434*	*2260* *EOY FY11/2641*		*66%*	*76%*	*86%*

DSC Fielding Through 12 Jul 11

How Does It Work?

Analyze & Correlate Data: Prognostics



What Does It Do?

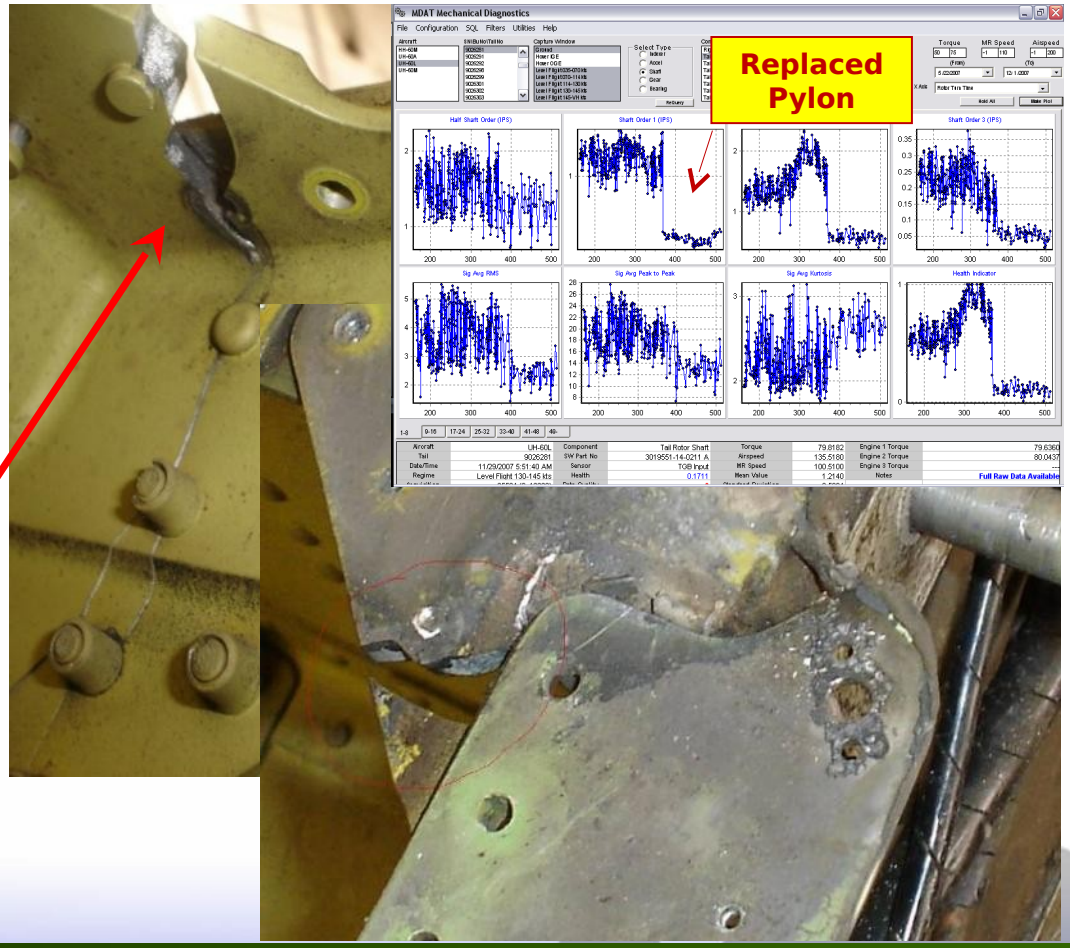
Improve Safety: Blackhawk Vertical Fin

Background

- Aircraft 90-26281 (Equipped With IVHMS), 5-101 AVN JUL 08
- Maintainer Detected a High Vibration Indication in the Tail Gearbox Input Accel.
- Inspection Revealed Numerous Cracks in the Tail Pylon. Detection Prevented Subsequent Damage and Potential AC Mishap. This On-condition Detection Identified Signatures That Can Be Used to Analyze Other Aircraft.

Conclusion

- Engineering Judgment That Within a Few Flight Hours, the Vertical Fin (and Thus Entire Tail Rotor) Would Have Separated From Aircraft, Leading to Catastrophic Mishap



Saved 1 UH-60L Potential Class A Accident
= $6M Aircraft And At Least 3 Crew Members

What Does MSPU Do?

Item	Action / Benefit
Main Rotor	AVA installation for main rotor smoothing. Allows for minor adjustments without requiring MTF
Tail Rotor	Eliminates AVA installation for tail rotor balancing. Allows for minor adjustments without requiring MTF.
Main Rotor Swashplate	AWR eliminates 50 Hr bearing inspection. Eliminates Maintenance Test Flight required after 50 hr bearing inspection
APU Clutch	Eliminates AVA installation for vibration check at APU installation and phase and increases APU mount special inspection from 250 to 500
Fwd Hanger Bearing	Safety Improvement w/Continous Diagnostic Monitoring. Increase TBO from 2500 to 2750
Aft Hanger Bearing	Safety Improvement w/Continous Diagnostic Monitoring. Increase TBO from 2500 to 2750
Main Trans Primary Acc Clutch	Safety benefit: Can tell if Primary acc clutch has failed and operating on secondary clutch
Nose Gearbox	Safety and Maintenance planning benefit. Provides early warning of failure, can remove NGB prior to chip light, preventing internal damage and Precautionary Landing

What Does IVHMS Do?

Item	Action / Benefit
Oil Cooler Axial Fan Bearing	**Eliminates AVA Installation Requirement for 120 Hour Inspection. Extends TBO of oil cooler fan assembly from 2500 to 3240 hours.**
Engine Output Drive Shaft	**Eliminates AVA Installation Requirement for 120 Hour Inspection. Eliminates AVA installation for high speed shaft balancing procedure.** **Replace w/Continuous Diagnostic Monitoring. MMH Saved per Inspection 3.3 hours. Downtime Saved per Aircraft 1.8 hours**
Main Rotor, Nose Absorber	**Eliminates AVA installation for main rotor smoothing and nose absorber tuning procedure.** **MMH Saved 17.2 Hours**
Tail Rotor	**Eliminates AVA Installation Requirement for 120 Hour Inspection. Eliminates AVA installation for tail rotor balancing procedure. MMH Saved 2.0 Hours**
Cabin Absorber	**Eliminates AVA installation for cabin absorber tuning procedure. MMH Saved 2.0 Hours**
Accessory Gearbox Spline Adapter	**Identifies potentially cracked splines reducing probability of generator, or gear damage due to adapter chips migrating into the gearbox.**

How Can We Improve?

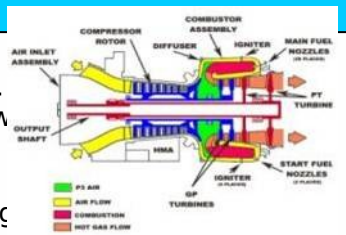
AMRDEC S&T is Working Technologies Across Entire Fleet

Purpose: Develop and demonstrate diagnostic, prognostic, and system health assessment technologies to enable transition to Condition Based Maintenance

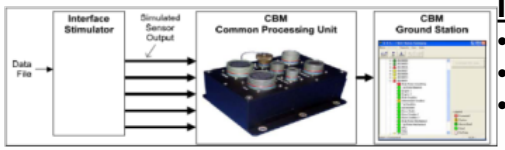
Propulsion

- Continuous pow

  assurance
- PHM for rotating components
- Power management

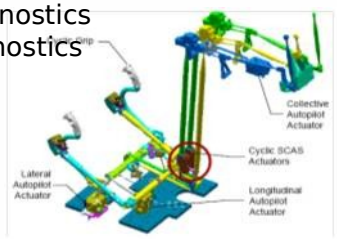


System Integration



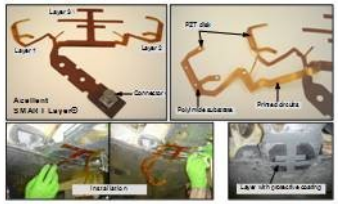
Flight Controls and Hydraulics

- Mechanical controls prognostics
- Pump and Actuator prognostics
- Hose chafing detection



Structures

- Corrosion detection
- Damage



Rotors & Hub Components

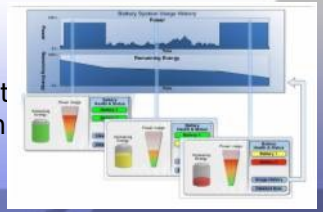
- Hub component diagnostics
- Blade damage detection
- Usage monitoring-direct load measurement
- Acoustic rotor blade delamination robot

Drive and Mechanical Systems

- Gear fault detection
- Wear detection prognostics
- Non-metallic debris monitoring
- Corrosion detection

Electrical/Electronic Systems

- Wiring prognostics/chafing
- Electrical component prognost
- Electronic power supply progn



How Can We Improve?

Implement Tactics, techniques & Procedures